IV. *An Account, by Mr.* John Eames, *F. R. S. of a Book entitled,* TRAITE PHYSIQUE ET HISTORIQUE DE L'AURORE BOREALE, Par Mr. DE MAIRAN. Suite des Memoires de l'Academie Royale des Sciences, Année MDCCXXXI: *Or, a Philoſophical and Hiſtorical Treatiſe concerning the* Aurora Borealis; *By Mr.* De Mairan, *being a Supplement to the Memoires of the Academy of Sciences for the Year* 1731.

THE frequent Appearances of the *Northern Lights* in ſeveral Parts of *Europe* and *America*, and the ſurpriſingly beautiful *Phænomena* that have been obſerved in ſome of them, ſuch as the Rainbow-Colours, Canopy, *&c.* have very juſtly engaged the Philoſophers of the preſent Age in a Search after the Cauſes of them. Several Hypotheſes have been invented and propoſed by the Learned, in order to explain theſe things. Moſt of them ſuppoſe theſe *Phoſphorus* like Appearances to proceed from certain *Effluvia*, either perſpired out of our Earth, or at leaſt paſſing through it. But our ingenious Author has thought of a Cauſe very diſtant, as well as very different from all theſe, *viz.* the Atmoſphere of the Sun, which at ſome times ſhews itſelf under the Appearance of a Light, which he calls the Zodiacal Light, but at other times produces an *Aurora Borealis.*

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alis. The Zodiacal Light is the purer unmixed Atmoſphere of the Sun: But an *Aurora Borealis* is the Effect of the Solar Atmoſphere, conſequent upon its making a Deſcent into, and blending itſelf with the Atmoſphere of our Earth, at certain Times and Seaſons of the Year. But a more particular Account of this Matter will be given hereafter.

The learned Author of this Work has taken a great deal of Pains in compiling it. He has look'd over the Accounts of Meteors, from the fifth Century down to the preſent Time, in the Hiſtorical Part; and has ranged them in very good Order, in regard of the ſeveral Returns of this *Phænomenon*, making ſuch Remarks by the way, as ſerve to ſupport his Solution of it in the Philoſophical Part.

By a Return he does not mean barely a ſingle Appearance, but a Series of them after a Ceſſation or Non-appearance for ſeveral Years. Thus he makes but twenty-two Returns from the Year 400 to 1716, while the ſeveral Appearances of theſe Lights from 1707 to 1710, after a ceaſing to be ſeen for twenty Years, are reckoned but one Return.

Mr. *Mairan* hopes the learned World will take the whole Performance under their Conſideration, and give their free Thoughts upon it.

The Work conſiſts of five Sections; the firſt gives a ſhort Hiſtory of the Zodiacal Light. In the ſecond he treats at large of the Atmoſphere of the Earth; its Altitude, and the Height of the *Aurora Borealis* in it, and the Excluſion this Circumſtance gives to ſome of the Cauſes, which have been already aſſign'd, of this *Phænomenon.* In the third he propoſes the Cauſe, and accounts for the Formation

tion of this Appearance in general, and then deſcends to a Detail of the ſeveral Particulars, adding the Solution of each. The next Section is employed in relating the Hiſtorical Proofs of his Hypotheſis concerning the *Northern Lights*, taken from the Records we have of ſeveral Appearances of thoſe Lights, to be met with in ancient Authors, compared with thoſe of the Zodiacal Light, their ſuppoſed Cauſe, and the Situation of the Earth in her annual Orbit at thoſe times. The laſt Section conſiſts of twenty-eight curious Queſtions concerning ſeveral other *Phænomena* of Nature, which the ingenious Theoriſt believes to have a Dependance upon his new Hypotheſis, and explicable by it.

But a more particular Account of theſe Matters may juſtly be expected.

Mr. *Mairan* begins the whole with laying before the Reader a ſhort View of his Hypotheſis concerning the Nature of an *Aurora Borealis*, defining his Terms as he goes along.

The *Aurora Borealis*, ſays he, is a luminous *Phænomenon*, ſo called from the Place of its Appearance, uſually in the Northern Parts of the Heavens, and with a Light near the Horizon, reſembling that of the Morning Dawn. This Name is ſuppoſed to be firſt given it by Mr. *Gaſſendi*, but it appears otherwiſe, from a Place in his Animadverſions on *Diogenes*, quoted by Mr. *Mairan*.

The Cauſe of an *Aurora Borealis*, in general, he takes to be a Light called the Zodiacal Light, which is in reality nothing elſe but the Atmoſphere of the Sun ſpread on each Side of him along the Zodiack, in the Form of a Pyramid. This ſometimes is extended

tended to ſuch a Length as to reach beyond the annual Orbit of our Earth, and in theſe Circumſtances ſometimes to blend itſelf with our Atmoſphere, and being of an Heterogeneous Nature, produces the ſeveral Appearances which are obſerved in, and uſually compoſe the *Northern Lights.* This he undertakes to explain, and prove more largely, in the ſequel of the Work.

A Diſcourſe upon the Nature of the *Zodiacal Light*, or Sun's Atmoſphere, and the Matter of which it conſiſts, is the Subject of the third Chapter. That it is very different from the Ambient Æther, he ſays is evident, in that the Æther reflects none of the Light of the Sun, is extremely rare, and altogether imperceptible. Whether the *Zodiacal Light* of the Solar Atmoſphere be any Emanation from the Body of the Sun, a Species of Efferveſcence, or Depuration of its groſſer Parts, an Amaſs of Heterogeneous Parts diffuſed in the Æther, that meeting from all Parts, tend towards the Sun, *&c.* he will not undertake to determine.

It is enough for his Purpoſe, that it is of a luminous Nature, whether in itſelf, or becauſe ſtrongly illuminated by the Rays of the Sun, whoſe Body it environs. He does not deny but that it may be alſo of an inflammable Nature, nay actual Flame or Fire, though very fine and rare.

He obſerves, that the Form in which the Atmoſphere of the Sun is commonly ſeen in total Eclipſes of the Sun, is Round, though ſometimes Conical, of which he gives us a Figure.

At all other times it moſt uſually preſents itſelf to us in the Form of a lucid Pyramid, or Lance, lying oblique

oblique to the Horizon, along the Zodiac, and for that reaſon call'd by the late Mr. *Caſſini* the *Zodiacal Light*. Mr. *J. Childrey* in his Hiſtory of the Natural and Artificial Rarities of *England*, deſcribes it thus. There is another thing which I muſt needs recommend to the Obſervation of Mathematical Men, which is, that in *February*, and for a little before, and a little after that Month, as I have obſerved ſeveral Years together about Six in the Evening, when the Twilight has almoſt departed the Horizon, you ſhall ſee a plainly diſcoverable Way of the Twilight, ſtriking up towards the *Pleiades*, and ſeeming almoſt to touch them. It is to be obſerved any clear Night, but it is beſt ſeen *illuni Nocte*. There is no ſuch Way to be obſerv'd at any other Time of the Year, that I can perceive, nor any other Way at that time to be perceived darting up elſewhere; and I believe it has been, and will be conſtantly viſible at that Time of the Year. But what the Cauſe of it in Nature ſhould be, I cannot yet imagine, but leave it to farther Enquiry.

Upon a farther and cloſer Enquiry, and Conſideration of this Matter, the ingenious Author, Mr. *Mairan*, tells us, he takes it to be the Solar Atmoſphere, and therefore treats at large of the Reality, Viſibility and Antiquity of this Light.

I beg leave to tranſcribe the Accounts of the ſame, given in by the Reverend Dr. *Derham*, Canon of *Windſor*. He informs us, that about a Quarter of an Hour after Sun-ſet, *April* 3, 1707, he perceived in the Weſtern Parts of the Heavens a long ſlender Pyramidal Appearance, perpendicular to the Horizon. The Baſe of this Pyramid he judged to be the Sun, then below the Horizon. Its *Apex* reached fifteen or twenty Degrees above the Horizon: It was throughout of a ruſty red Colour, at firſt pretty vivid and ſtrong, but the Top part much fainter than the Bottom nearer the Horizon. He did not remember he ever ſaw any thing like it, except the white Pyramidal Glade, which is now entitled by the Name of the *Aurora Borealis*, that being like it except in Colour and Length. Again, on the 20th of *March*, 171⅚, in the Evening, he eſpied a very odd Sort of Light in the Conſtellation of *Taurus*. This Glade of Light had the ſame Motion that the Heavens had, and was much like the Tail of a Comet, but pointed at the upper End. This Light, I doubt not, is ſuch as Dr. *Childrey* firſt obſerved in *England*, and *Caſſini* and others afterwards in *France*.

Mr. *Mairan* proceeds to give an Account of the true Figure, Extent, Situation, &c. of this Light, or Atmoſphere of the Sun. Its true Figure he judges, with Mr. *Fatio*, to be lenticular, and gives a Projection of it upon the Plane of the Sun's Equator, the Eye being ſuppoſed in the Axis of the Sun produced through his South Pole at ſuch a Diſtance as makes the Solar Atmoſphere appear under the Angle of forty-five Degrees. In it you have a View of the Nodes, Poles, Limits, Declination and Extent, paſſing through and beyond the Orbits of *Mercury* and *Venus*, and in ſome Parts beyond the *Orbis Magnus*. This laſt Article of its Extent he demonſtrates from ſeveral Obſervations of the Elongations of the Apex of this Pyramid from the Centre of the Sun. This has been found to be ſometimes double that of *Venus*, and other times 90 Deg. and once or twice above

100,

100, whereas an Elongation of 90 Deg. gives the Diſtance of the *Apex* from the Sun equal to that of the Earth at the time of Obſervation.

This Section is cloſed with an Account of the Changes, both real and apparent, to which the *Zodiacal Light*, or Solar Atmoſphere is liable Its Length has been for ſome time upon the Increaſe, afterwards in a diminiſhing Condition, and has been altered ſo much in the Compaſs of thirty-ſeven Months, as to have been 30 Deg. longer at one time than at another. The Changes in Luminouſneſs, Denſity and Tranſparency, has likewiſe been found to be very conſiderable. Sometimes the *Zodiacal* Light has been ſo rare and weak as to be but juſt viſible, afterwards for a long time not viſible at all.

Hereupon our ingenious Author thinks proper to obſerve, that theſe Conſiderations may ſerve in ſome Meaſure to account for the Inconſtancy of the *Aurora Borealis*, as alſo for their Non-appearnce for ſome Years; ſince they owe their Original to, and have ſo cloſe a Connexion with the *Zodiacal Light*, whoſe Appearance is ſo uncertain. Add to this the *Zodiacal Light*, as he afterwards ſhews, muſt not only be of a ſufficient Length and Denſity, but the Earth muſt be in or near the Nodes, form'd by the Interſection of the Plane of the Sun's Equator with the Plane of the Eclipticks.

The ſecond Section treats at large of the Altitude of our Atmoſphere, and of that of the Region in it uſually poſſeſs'd by the *Aurora Borealis*. Under this Head he diſcourſes of the ſeveral Methods the Mathematicians have uſed to find the greateſt Heights of the Air, ſuch as the Duration of the Twilight, the Altitude of the *Mercury* in the Barometer, and rejects them as inſufficient for that Purpoſe; the Atmoſphere being much higher than what has been ever found by them, and conſiſting of a Fluid much finer than the groſs or common Air, the Height of which laſt only is meaſurable by theſe ways.

Mr. *Mairan* therefore goes on to ſettle the Altitude of the *Northern Lights*, after another manner, founded upon ſeveral Obſervations made at very diſtant Places at the ſame time, and fixes ſome *Auroræ Boreales* to be but one hundred Leagues, though others are no leſs than three hundred, and the far greater Number of them about two hundred Leagues above the Surface of the Earth.

Mr. *Cramer*, Profeſſor of the Mathematicks at *Geneva*, computes the Height of the *Aurora Borealis*, ſeen at the ſame time at *Geneva* and *Montpellier*, *Feb.* 15th, 1730, to be $\frac{112}{1000}$ of a Semidiameter of the Earth, *i. e.* about 160 Leagues.

Mr. *Meyer* has propoſed in the Memoires of the Academy of *Petersburgh*, a very ingenious Method of finding the Height and Diſtance of a *Boreal Arc*, from any Obſerver, by a ſingle Obſervation. Mr. *Mairon* applies this Method to ſuch *Auroræ Boreales* as were capable of it, and finds that the *Boreal Arcs* of ſeveral were no leſs than an hundred Leagues high.

It is on this account that in the next Chapter our Author conſiders ſome Solutions that have been offered to ſolve theſe Appearances of the *Northern Lights*, and ſets them aſide as inſufficient, becauſe they ſuppoſe Cauſes which have no Exiſtence, or at leaſt no Efficacy at ſo great a Height in the Atmoſphere.

The next Section is the principal, and is engag'd in explaining the ſeveral particular Appearances of the *Lumen Boreale*, ſuch as its Situation, ordinarily towards the *North*, declining a little towards the *Weſt*; its dark, duſky, circular Baſis, ſurmounted ſometimes with one or more luminous Arcs; from behind which Columns, or Streams of Light, ſeem to iſſue either perpendicularly or concentric with the Arcs; add to theſe the Rainbow-Colours, Flaſhes, Vibrations, and in the laſt Place, a Glory, Canopy, or *Corona*, form'd by a Concourſe of the Rays of the Matter of this *Phænomenon*, near the Zenith of the Place.

Mr. *Mairan* premiſes an Inveſtigation of the *Locus*, or Limit of the Attractive Forces of the Sun and Earth, ſo that a Particle of Matter placed any where in it, will be equally attracted by both, or tend as much towards the Earth as it does towards the Sun. He finds, that if in a Line connecting the Centres of the Sun and Earth, a Point be taken at the Diſtance of about 43 Semidiameters of the Earth from her Centre, that Point will be in this Limit, ſo that a Particle placed there, will not gravitate either towards the Sun or Earth, but remain in *Æquilibrio*, the equal and contrary Forces of the Sun and Earth deſtroying each other. The Uſe he makes of this is to ſhew, that an *Aurora Borealis* may poſſibly be formed by a Deſcent of the *Zodiacal Matter*, lying between this Point of *Æquilibrium* and the Earth; tho' it does not reach ſo far as to involve the Earth itſelf. But the *Aurora* in this Caſe will be an incompleat and particular one.

The *Lumen Boreale* ordinarily appears in the Northern Parts of the Heavens, becauſe tho' the whole Atmoſphere of the Earth be involved in the *Zodiacal Matter* (or Solar Atmoſphere) yet 'tis thrown off both ways, from the Equatorial towards the Polar Regions.

This is owing to a double Cauſe, the firſt is the centrifugal Force, ariſing from the diurnal Motion of the Earth, which being greateſt at the Equator (and gradually leſſening as you approach the Poles, where it vaniſhes) makes greateſt Oppoſition there, and not only hinders the Entrance of the *Zodiacal Matter* into the Earth's Atmoſphere, near the Equatorial Region, but turns it aſide into a Courſe towards each Pole; and the Author does not queſtion but an *Aurora Auſtralis* might be ſeen at proper times in the Southern Temperate Zone, juſt as an *Aurora Borealis* is in ours, which is Northern, attended with ſimilar *Phænomena*, were there but attentive Obſervers.

The ſecond Cauſe is the progreſſive Motion of the Earth in its annual Orbit near one half of the Year with the *North Pole* foremoſt, and in the other half with the *South Pole*, moving thro' the *Zodiacal Matter*.

The natural Conſequence of which will be a heaping up of Matter, more on the Polar Regions than the Equatorial or Temperate, and this accounts in part for the Declination of the Centre of the luminous Arcs, ſometimes near ten Degrees from the *Pole*; the Direction of this Motion of the Earth not coinciding with the Direction of the Axis of the Earth, at thoſe times.

The dark Arcular Segment next the Horizon appearing like a heavy black Cloud, or Miſt, is form'd out of the denſeſt and ſpecifically heavieſt Parts of the *Zodiacal Matter*, which in their Deſcent muſt ſink deepeſt into the Earth's Atmoſphere, and are leaſt inflammable in their Nature, while the rarer and lighter Parts, which are more inflammable and luminous, if not actually inflam'd, form the Arc or Arcs that lie above the dark Segment. The ingenious Author ſpeaks of a *Fort de l' incendie*, a Place where the *Zodiacal Matter* collected together, and moving or paſſing thro' it, is actually turn'd into Flame. Thus long Trains of deſcending *Zodiacal Matter* arriving in their Deſcent at this Place, being kindled, or at leaſt reflecting the Light of that *Incendium*, produce the ſeveral Columns or Streams of Light that appear above, or behind the obſcure circular Baſe, or luminous Arches.

The Breaks that are ſometimes viſible in theſe Arches, are occaſioned by the Deſcent and Paſſage of ſeveral diſcontinued Trains and Flakes of the denſer and leaſt inflammable Parts of the *Zodiacal Matter*, between the Eye of the Spectator and the luminous Arch.

The various Colours ariſe from a Separation of the Rays of Light from each other, either by a ſort of Filtration in paſſing thro' Mediums of different Denſities, or by the Divergence of the differently refrangible and coloured Rays (or rather from the different Celerities of thoſe Rays, as the Author ſays he has explained more at large in another Place) after the manner that the Colours are formed in Clouds near the Horizon about the riſing or ſetting Sun.

To conclude, the Canopy in a compleat *Aurora Borealis* he looks upon to be an Object purely optical, a ſimple Appearance ariſing from a ſingular Diſtribution of ſeveral perpendicular Columns, or Trains of *Zodiacal Matter*, as he explains more at large in two Figures. This Exactneſs and Regularity in the Diſtribution makes it an uncommon *Phænomenon*; ſo that among an hundred *Auroræ Boreales* that have been obſerved, he has met with but three attended with a *Corona*.

What remains, is only to take Notice of ſome of the Queries which relate to ſeveral Appearances in Nature, that ſeem to be explicable by our Author's Hypotheſes of a Solar Atmoſphere, ſuch as the *Nebulæ*, or lucid Spots obſerv'd among the fix'd Stars, the Spots in the Sun, the Atmoſphere and Tails of Comets, *&c.*

The *Nebulæ* are certain luminary Spots or Patches, which diſcover themſelves only by the Teleſcope, and appear to the naked Eye like ſmall fix'd Stars. They are ſix in Number, and are accurately deſcribed in *Philoſoph. Tranſact.* N° 347. Some of them have no Sign of a Star in the middle of them, and are properly *Nebulæ*, others have, and then are called *Nebuloſæ*. They are look'd upon by ſome to be in reality nothing elſe but the Light coming from an immenſe great Space in the Æther, thro' which a lucid Medium is diffuſed, that ſhines with its own proper Luſtre, making a perpetual uninterrupted Day, by no means owing to the Illumination of a central Body, or Star.

But Mr. *Mairan* ſeems to be of another Mind, and queries thus: Since the fix'd Stars are Bodies of the

the ſame Nature with our Sun, may not ſome of them have Atmoſpheres ſurrounding them ſo luminary and extended, as to become viſible to us by a Light eaſily diſtinguiſhable from that of the central Body, and may not Atmoſpheres of others be ſo denſe as well as luminous, and extended, as may ſuffice to obfuſcate (to uſe the Author's Expreſſion) the Light of the Star involved in it? Are not the *Nebuloſæ* of the former Sort, and the *Nebulæ* of the latter? The lucid Spot in the *Cingulo Andromedæ*, which after *Hevelius* our Author continues to call a *Nebuloſa*, has been found by the late Mr. *Caſſini* to reſemble the *Zodiacal Light* in ſome Circumſtances, and by Mr. *Kirch* to have ſuffer'd ſome Changes appearing and diſappearing by turns.

Mr. *Mairan* obſerves by the way, that this Spot was firſt diſcover'd, not by Mr. *Bullialdus* in 1660, as is commonly believed, but by Mr. *Simon Marius* in 1612, who fully deſcribes it in the Preface to his *Mundus Jovialis*.

The luminous Space round the *Nebuloſæ* of *Orion's Sword*, diſcover'd and deſcribed by Mr. *Hugens*, he takes to be an Aſſemblage, or Sum Total of the ſeveral Atmoſpheres of the Stars, plainly viſible within that Space, and it may be of ſome others that are concealed from our View. The Irregularity of the Shape is no Difficulty to him, it ariſing from the different, and to us ſeemingly irregular Poſitions of their Atmoſpheres. He adds, as a Confirmation of his Hypotheſis, that the Brightneſs and very Figure of this Space has ſuffered ſome Alterations ſince Mr. *Hugens*'s Time. That one of the Stars delineated by Mr. *Hugens* without any ſurrounding Light, has ſince been found to have a pale Light like an Atmoſphere ſurrounding it.

Quer. 2. Is not the Solar Atmoſphere liable to frequent Fermentations, and ſubſequent Precipitations of its groſſer Parts towards the Surface of the Sun? and are not the different Degrees of Brightneſs and Tranſparency owing hereunto? ſince the Changes in our Air, or Atmoſphere, are not ſufficient to account for the Non-appearance of the *Zodiacal Light* in ſome convenient Seaſons, and clear Nights.

Quer. 3. May not the Spots, ſo often of late obſerved in the Surface of the Sun, be owing to theſe Precipitations of the groſſer Parts of the *Zodiacal Light*, ſince there ſeems to be ſome Analogy or Correſpondence between the Frequency, Ceſſation and Returns of theſe Spots, with the Ceſſation, Returns and Apparitions of the *Zodiacal Light*?

Quer. 4. Are not the Inferior Planets, *Mercury* and *Venus*, almoſt always immerſed in the *Zodiacal Matter*? and may not that be one Reaſon why 'tis ſo difficult to obſerve Spots in them? May not a Change, the Denſity, or Magnitude of the Solar Atmoſphere, be one Reaſon why the Aſtronomers at *Paris* have not been able to obſerve thoſe Spots in the Diſk of *Venus* that have been taken Notice of, and deſcribed by Mr. *Bianchini* at *Rome*, a little before, ſince the Teleſcopes at *Paris* were of equal Length and Goodneſs?

Quer. 20. May not the Augmentation of the Quantity of Matter in the Earth and Inferior Planets, by the continued Accumulation of the *Zodiacal Matter* on their Surfaces during a long Courſe of ſeveral Ages, produce, among other things, ſome Alteration in their Periodical Motions?

Quer. 21, *&c.* May not the Atmoſphere and Tail of a Comet be owing to the *Zodiacal Matter*, which the Comet during its Paſſage through the Atmoſphere of the Sun intercepts, and afterwards carries away with it, in its Aſcent from the Sun?

Quer. 28. Is not the Earth ſafe enough from all Danger of any Inundation, much more of an Univerſal Deluge, tho' it ſhould paſs thro' the Atmoſphere, or Tail of a Comet? ſince the Effects of ſuch a Paſſage can only be an *Aurora Borealis*, whoſe Matter is not at all of a watry vaporous Nature? A Conflagration rather than an Inundation might have been imagined to be the natural Conſequence, but Experience informs us, that if this Hypotheſis be admitted as genuine, that our Earth has been entirely plunged in this *Zodiacal Matter* without any ſenſible Heat attending it.